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# Comparative Evalution of Resin Based Sealer on Fracture Resistance of Endodontically Treated Teeth: An in Vitro Study

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## Abstract

**Background:** Root canal therapy offers a chance to treat diseased or damaged teeth so they can continue to function normally in the dentition, but it also reduces the tooth's structural integrity, which lowers the teeth's resistance to fracture. Root canal sealers have recently been developed, and they are rumored to improve the bond strength between root canal filling materials and the root dentin, increasing the root's resistance to fracture. The aim of the study was to compare between AH Plus and MetaSEAL resin based root canalsealer on fracture resistance of endodontically treated teeth.

**Materials and methods:** Thirty freshly extracted human mandibular premolar teeth were selected according to inclusion and exclusion criteria. All of them were decoronated up to cemento-enamel junction, and to have a 14 mm root length. Then teeth were divided into three groups (n=10). Group-1: AH Plus sealer, Group-2: MetaSEAL endodontic sealer and Group-3: neither instrumented nor obturated served as negative control. First two groups were instrumented using ProTaper rotary file (Dentsply, Sirona) system up to F3 fileas the final master apical file. Single cone obturationtechnique was carried out to both experimental groups. Fracture strength test was done by universal testing machine (Hounsfield, $H_1$OKS,UK). The force required to fracture was recorded in Newton. The result was statistically analyzed using one-way analysis of varience (ANOVA) and post hoc test (Tukey's HSD).

**Results:** Group-1(AH Plus) showed higher fracture resistance force values than group 2 (MetaSEAL) significantly. There was insignificant difference between group 1 and 3.

**Conclusion:** The use ofAH Plus sealer could produce more fracture resistance than MetaSEAL resin based sealer of endodontically treated teeth.

**Key words:** AH Plus; Fracture resistance; MetaSEAL.

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## Introduction

The amount of sound tooth structure that is still there directly correlates to the strength of an endodontically treated tooth. Removal of caries, access preparation, canal instrumentation and preparation for final restoration all leads to the loss of tooth structure. The reason behind the root fracture of an endodontically treated teeth are the dehydration of dentin after endodontic therapy, excessive pressure during obturation and the removal of tooth structure during endodontic therapy.[1] Obturation materials are considered as a prime element to provide strength of endodontically treated teeth. Gutta-percha along with sealer is the most commonly used root canal obturation material.[2] Sealer must have adequate cohesive strength to hold the obturation together as well as adhere to both dentin and the core material. This hypothesis potentiates the development of adhesive root canal sealer.[3] Adhesion is important due to its superior sealing ability which in turn results in less coronal and apical leakage and the prevention of displacement of filling material during restorative procedure.[4] A prime requisite of a root canal sealer is having a higher fracture resistance and forming a successful monoblock in conjunction with the core filling material.[5]

Gutta-percha has a low modulus of elasticity hence to improve the root strength bond ability of the sealer to root dentin is of paramount importace.[5] Therefore, clinicians have long sought to reinforce the tooth structure with adhesive dental materials.[6]

There are advent of different adhesive sealer that facilitate adhesion to the root canal dentin results in mechanical interlocking thus increases the fracture resistance of endodontically treated teeth.[7] AH Plus (Dentsply, Konstanz, Germany) is an epoxy resin based sealer has been used as a standard material after its commercial availability used in root canal obturation with the advantages of good retention and better wettability to dentin along with gutta-percha, leading to a good seal of the canal, and it penetrate deeper into the micro-irregularities of dentin surface, as well as inside the lateral canals.[8,9] It has been used as a standard material after its commercial availability.[9] Epoxy resin based sealers are widely used for their resorption resistance and dimensional stability.[10]
MetaSEAL (ParkellInc, Edgewood, NY, USA) is a commercially available fourth generation self-adhesive, dual-cure polymethyl methacrylate resin based sealer available in the liquid and powder form. The liquid contains an acidic 4-methacryloxyethyle trimelliate anhydride (4-META) resin monomer and photoinitiator, while the powder consists of a mixture of zirconia oxide filler, silicon dioxide filler and a polymerization initiator[11].Therefore, it eliminates the need for a separate etching and bonding step, reduce the application time and decrease the number of errors that might occur during each bonding step [12].It has the ability to simultaneously bond to the dentin and the core materials and is capable of diffusing through the demineralized dentin surface to promote the formation of the hybrid layer after polymerization[13].It also improves the bond strength and resistance to push out test indicating its potentialbonding to the interradiculardentin with the evidence of creation of hybrid layer-like structure along the gutta-percha-sealer interface and improve the fracture resistance of endodontically treated teeth[14,15]. Thus the study was designed to compare between two different resin based sealer like AH Plus and MetaSEAL.

**Materials and methods**

Ethical permission to carry out the study was taken from the Institutional Review Board of Bangabandhu Sheikh Mujib Medical University (BSMMU). This Quasi experimental study design was conducted within 12 months after approval of IRB. This study was conducted in the Department of Conservative Dentistry and Endodontics, BSMMU and in the PP & PDC Department of Bangladesh Council of Scientific and Industrial Research (BCSIR). For this study thirty freshly extracted human mandibular premolar teeth were selected that were extracted for orthodontic treatment purpose. The buccolingual (5-7mm) and mesiodistal diameter (4-6mm) of the roots were measured with a digital varnier caliper.Then teeth were stored in normal saline till the further period of the study. All soft tissue and debris was removed by using an ultrasonic scaler tips. A dental surgical loupe at 2.5× magnification was used to rule out any pre-existing root fracture, cracks and craze line. Preoperative radiograph of extracted teeth was taken to determine the root canal morphology, open apices, calcification, multiple canals and fracture. The teeth were decoronated up to the cemento-enamel junction with a diamond disk and length were standardized to make a 14 mm long specimen. Ten teeth were kept aside and not subjected to biomechanical preparation. For the remaining twenty teeth the access cavity were prepared with a diamond round bur no # 4 and the apical foramen patency was determined with a 10 no K file. Then a 15 no k-file (DentsplyMaillefer, Ballaigues, Switzerland) with a silicone rubber stop was inserted, until its tip was just visible at the level of apical foramen. This procedure was performed under a magnifying glass at a magnification of ×16. Then the silicone rubber stop was adjusted to a specific reference point on the decoronated tooth, after that the file was removed from the root canal and working length was established 1mm short of the apical foramen.All root canals were instrumented by rotary ProTaper file system (Denstply, Sirona) to size F3, corresponding to an apical size of 30. Along with this instrumentation, irrigation was done with 5 ml 5.25% sodium hypochlorite with a 27-gauge needle. Recapitulation was performed with no.15 k file to keep the apical foramen patent. After instrumentation Smear layer was removed by irrigation with 5 ml of 17% Ethylene Diaminete Traacetic Acid (EDTA). Final rinse was done with 5 ml of sterile water to remove any residue of acid. All of the prepared canals were dried with sterile paper points.Then teeth were randomly divided into twogroups, group-1 for AHPlus sealer and group-2 for MetaSEAL sealer.

First two groups consist of ten teeth which were subjected to biomechanical preparation, sealer was mixed according to the manufacturer's instructions and all canals were obturated with single cone technique.

One negative control group of ten teeth was taken and the teeth were not subjected to biomechanical preparation.

After that the quality of root canal obturation for every sample of group-1 and group-2 were confirmed by radiograph. All the roots were stored at $37^0$C in 100% relative humidity for 7 days to ensure complete setting of sealers.

Obturated roots embedded in acrylic blocks exposing 8 mm of root length were placed in UTM machine to determine the fracture resistance values. Force was applied along the center of the canal at an angle of $0^0$ at a rate of 1mm/min until the root fracture occurred.At this point, the test was stopped, and the force needed to break the root was measured in Newton.

The fracture load data were analyzed by using statistical analysis using SPSS V.26, one-way ANOVA was done. Then, Tukey's multiple post hoc (HSD) test was done to compare between groups.

**Results**

The resin based sealer AH Plus and MetaSEAL were used to observe the root strengthening effect in comparison with the negative control group. Here, the negative control group shows the highest fracture load values than experimental groups. In experimental groups AH Plus sealer shows statistically significant difference than MetaSEAL group.

The highest meanfracture resistance was found in Group 3 (491.600 ± 21.2294 N) followed by group-1 (AH Plus) (470.69± 34.69N) and Group-2 (Meta SEAL) (373.600 ± 20.0714). The ANOVA test (Table-I) showed significant differences among groups by setting a level of significance at 0.05. Post hoc Tukey's (HSD) test was performed for multiple comparisons between groups (Table II). It was seen that AH Plus sealer showed a statistically significant difference when compared with other groups ($p<0.05$). The negative control group showed a significant differences with group-2 (MetaSEAL) with no significant difference with group-1(AH Plus).

**Inter group comparison using one-way ANOVA and post hoc (Tukey's HSD test)**

On applying post hoc test and setting a level of significance at 0.05, it was seen that group 3 (Negative control) showed highly significant difference when compared with the MetaSEAL ($p=0.000$). Group 1 (AH Plus group) showed statistically significant difference ($p=0.000$) when compared with group 2 (MetaSEAL group). There is no significant difference between group 1(AH Plus) and group 3 (Negative control) $p=0.881$. The intergroup comparison is depicted in Table II.

**Table I** Comparison of means of different sealers group in matched taper single cone technique

| Variable | Materials | n | Mean±SD (n) | Statistics |
|---|---|---|---|---|
| Vertical load required to fracture roots | AH Plus (Group-1) | 10 | 470.690 ± 34.6991 | F=17.734 p<0.0001 |
| | MetaSEAL (Group-2) | 10 | 373.600 ± 20.0714 | |
| | Negative (Unobturated) Control group (Group-3). | 10 | 491.600 ± 21.2294 | |

Table I shows the relationship between fracture resistant force and the materials used in matched taper single cone technique. One-way ANOVA was also conducted here and the assumption of homogeneity of variance can be assumed. Here $F=17.734$, $p<0.0001$, so there was a statistically significant differences at the $p< 0.05$ in fracture resistant force for the groups.

**Table II** Post hoc test (Tukey's HSD) for multiple intergroup comparisons between the sealers group

| Multiple Comparisons Tukey HSD (I) Group | (J) Group | Mean Difference (I-J) | Std. Error | Sig. | 95% Confidence Interval Lower Bound | Upper Bound |
|---|---|---|---|---|---|---|
| AH Plus | Meta SEAL | 97.0900* | 28.3525 | .008 | 20.730 | 173.450 |
| | Negative control | -20.9100 | 28.3525 | .881 | -97.270 | 55.450 |
| Meta SEAL | AH Plus | -97.0900* | 28.3525 | .008 | -173.450 | -20.730 |
| | Negative control | -118.0000* | 28.3525 | .001 | -194.360 | -41.640 |
| Negative control | AH Plus | 20.9100 | 28.3525 | .881 | -55.450 | 97.270 |
| | Meta SEAL | 118.0000* | 28.3525 | .001 | 41.640 | 194.360 |

*. The mean difference is significant at the 0.05 level.

In Table II AH Plus showed significant difference compare to MetaSEAL group with p values .008. There was no significant difference ($p=0.881$) between negative control and AH Plus group.

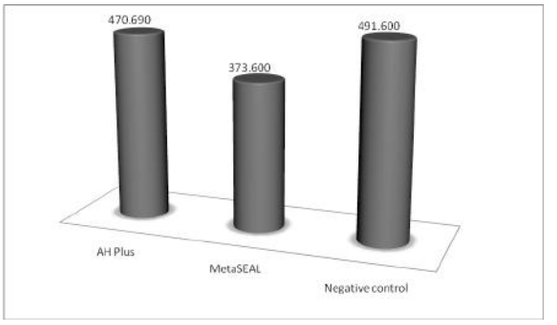


**Figure 1** Mean Value Difference between Sealer Groups and Negative Control Group

**Figure 2** Customized setup in universal testing machine

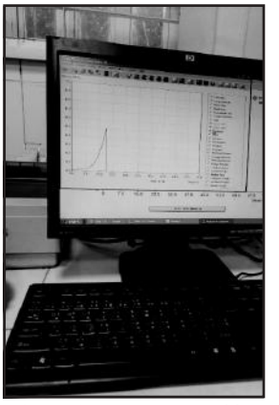

**Figure 3** Force measured in newton

## Discussion

In this study, the vertical load required to root fracture, for AH Plus group was (470.690 ± 34.6991N) followed by MetaSEAL373.600 ± 20.0714 Nrespectively. But the negative control (Uninstrumented) group showed the highest vertical load of 491.600 ± 21.2294N.Higher fracture resistance force values as was found in the present study in AH plus sealer group is supported by the previous studies.[16,17] Mandav et al who adopted a deferent design in experiment, simulated periodontal ligament with paste of silicon-based impression material up to 2mm apical to the CEJ and tooth was mounted vertically to a depth of 2mm below the CEJ in polystyrene resin block. Even though AH plus sealer group came out with higher fracture resistance values than MetaSEAL group, like present study.[16] Similarly, Lawson et al chosen the push-out bond strength test design to compare AH plus sealer with MetaSEAL sealer. He also concluded that AH Plus sealer had superior fracture resistance than that of the MetaSEAL in their study.[17] Thus, both the study strongly supports that AH plus sealer provide superior fracture resistance value than MetaSEAL irrespective of study design.

Adhesion between dentin and resin-based sealers are the results of a physicochemical interaction, resulting in development of a bond and allowing greater adaptation between fillers and root dentin.[18] In static situation, the adhesionprovided by sealer particles eliminatethe spaces that might allow fluid infiltration into the dentin-sealer interface. In dynamic condition, this adhesion is necessary to prevent dislodgement of the filling material, thus reduce the risk of contamination and re-infection of the tooth[19].This indicates retention of the filling material might be increased by mechanical locking within the dentinal tubules,thus reinforcing the root canal dentin and improves its fracture resistance. With much attention on the adhesive properties of epoxy-resin based sealer, the AH Plus sealer was compared with methacrylate resin based sealer on the fracture resistance of root dentin.[20]

On the other hand, the result of Sarangi et al, are not in agreement with the present study. In the study of Sarangi et al MetaSEAL had higher resistance (1.49 ± 0.09 MPa) than AH Plus (0.90± 0.04 MPa) and the difference in bond strength was statistically significant (p=0.0000). Significantly higher fracture resistance with MetaSEAL group as was found in their study may be due to use of resilon point instead of gutta-percha as filler material with both the experimental sealers.[14] It has been claimed that "resilon" is a high-performance industrial polyurethane used as a core filling material to which resin sealer bonds and attaches to the etched root surface thereby forms a "monoblock"which in turns increases fracture resistance of obturated roots.[11,13]

The study of Sa sen et al and Saba et al showed uninstrumented root provide highest fracture resistance force than any other group with no significant differences with AH Plus sealer group that is consistent with our study.[20,21] Sa senet al showed that AH Plus sealer is capable of increasing the fracture resistance of prepared root canal due to its higher creep capacity and longer polymerization period.[20] This result implies that teeth filled using AH Plus sealer in combination with GP have the capability to strengthen the root that is nearly similar to natural tooth in terms of fracture resistance.

According to Pukhan et al higher fracture resistance force values of AH Plus sealer is due to the formation of covalent bond by an open epoxide ring to any exposed amino groups in collagen fiber.[5] The creeping property and long polymerization period increases the mechanical interlocking between the root canal dentin and the sealer.[22]

In the present study thirty teeth were allocated in different experimental groups and control group. It was not known whether all stored teeth had comparable dentin in terms of strength and hardness. When extracted human teeth are used for this type of study, the potential for large uncontrollable variations may exists. Therefore, all controllable factors should be standardized as much as possible. Here we assign the teeth in different group by random selection and we controlled the dimension of the specimens, such as the root length and bucco-lingual and mesiodistal diameter as done by previous studies.[5] UTM machine was used in many studies for measurement of fracture force required to break the root. In this study, load was applied vertically along the longitudinal axis of the root as it entirely transfers the load to the root.[23] This would result in decreased bending moments and maximum stresses located to the cervical region. This study design is believed to mimic the clinical situation of teeth where roots are supported by the alveolar bone.[6]

In order to standardize the apical diameter of the enlarged root canals, all roots were prepared to Pro Taper size F3, corresponding to the apical size 30. Additionally, all teeth had their crowns removed prior to strength testing.This led to a condition that, in the majority of cases, is not clinically relevant and may have further compromised the teeth[24]. Thus, it has to be kept in mind that the reported force applied to the point of fracture are not absolute but only relative between the different groups, and thus they cannot transfer the true clinical situation.[25] Moreover, the compressive force used in this study fundamentally differed in nature from masticatory force. A compressive force with a gradually increasing force of 1mm/min was applied using sharp pointed metal tip of 2 mm diameter mounted in universal testing machine. Unlike natural forces, which are constantly changing in kind, strength, and direction, this force was a static compression force that grew until it broke.

**Limitation**

- Sample size was small and purposive sampling technique was used
- Only resin-based sealers were tested to evaluate the strengthening effect of the sealer.
- Only compressive force was evaluated.

**Conclusion**

It can be concluded that the fracture resistance of teeth obturated with AH Plus and gutta-percha were significantly superior to teeth obturated with MetaSEALgroup but less than the negative control group.

**Recommendation**

AH Plus can be used as a root canal sealer for root canal obturation with gutta-percha to strengthen the endodontically treated teeth.

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**Contribution of authors**

RY- Initial research design, data acquisition, analysis, interpretation, manuscript drafting, critical revision and final approval.

AAM- Data Analysis, critical revision and final approval.

AKMB- Data analysis, interpretation, manuscript drafting, critical revision and final approval.

AG- Data analysis, critical revision and final approval.

SIM- Design, critical revision and final approval.

TZ- Acquisition of data, data analysis, drafting and final approval.

TF- Interpretation of data, critical revision and final approval.

**Disclosure**

All the authors declared no competing interest.

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